Polish Journal of Agronomy
2010, 3, 20–23

Effect of sowing rate on yields and grain quality of new cultivars of spring barley

Kazimierz Noworolnik

Department of Cereal Crop Production
Institute of Soil Science and Plant Cultivation – National Research Institute in Puławy
ul. Czartoryskich 8, 24-100 Puławy, Poland

ABSTRACT: Microplot experiments with spring barley were carried out on an experimental field IUNG-PIB in Puławy. They involved 3 sowing rates: 250, 350 and 450 seed m^{-2}. In 2004–2005 the cultivars Nadek, Sebastian, Widawa and Kirsty were investigated, and in 2006–2007: Toucan, Mauritia, Nagradowicki and Tocada. The experiments were conducted on good wheat complex soils (heavy loamy sand on light loam). All cultivars of spring barley responded with yield increase to the increase of sowing rate from 250 to 450 seed m^{-2}. Widawa, Mauritia, Nagradowicki and Tocada showed a higher yield increase in response to high sowing rate compared to medium rate of 350 grains m^{-2}. The increase of grain yield showed by all cultivars at high sowing rate was the result of an increase in the number of ears per unit area (to the highest degree in the cultivar Mauritia). Grain weight per ear (averaged across cultivars) was significantly higher at low sowing rate. The increase in the protein content in grain at high sowing rate was recorded for the cultivars Widawa, Kirsty, Nagradowicki and Tocada. Significantly positive effect of high sowing rate on grain plumpness was found in: Nadek, Sebastian, Toucan and Mauritia cultivars.

key words: spring barley, sowing rate, grain yield, protein content, yield components

INTRODUCTION

The synthesis of research results on the effect of different crop management-related, environmental and biological factors on spring barley yield showed that sowing rate is the strongest factor interacting with other factors on grain yield and yield components (Noworolnik, 2003). Different cultivars of spring barley react differently to an increase in sowing rate (Farack, Hansel, 1987; Kozłowska-Ptaszyńska, 1993; Jedel, Helm, 1995). It is related to their different tillering ability and different light requirements. A great number of recently introduced new malting and fodder cultivars of spring barley gives the reason for a systematic research on their requirements as to the optimal sowing rate in relation to grain yield and its quality. A good malting quality of the cultivars is related to a low protein content of the grain, while the reverse is true of fodder quality. Malt parameters are significantly dependent on barley grain plumpness.

The aim of the research was to examine the reactions of new cultivars of spring barley (yield, yield components, and protein content) to the increase in sowing rate. Moreover, it is important to compare the cultivars for their productive tillering and for the number of grains per ear, because those features are not determined by COBORU. The research hypothesis assumed different impact of sowing rate on yields and protein content in barley cultivars. The ones with weaker tillering are supposed to react more positively to higher sowing rate

MATERIAL AND METHODS

Microplot experiments with spring barley were conducted on an experimental field of IUNG-PIB in Puławy. They included 3 sowing rates: 250 (low), 350 (medium) and 450 (high) seed m^{-2}. In 2004–2005 the cultivars Nadek, Sebastian, Widawa and Kirsty were investigated, and in 2006–2007: Toucan, Mauritia, Nagradowicki and Tocada. The experiments were set up on good wheat complex soil (heavy loamy sand on light loam), on a field previously cropped to potatoes and laid out as a split-plot design with four replications between April 2 and 12. The soil was high in phosphorus, potassium and magnesium. Fertilization of 60 kg N, 22 kg P and 58 kg K per ha was used. Barley was manually sown at an amount higher than its sowing norm, and after the emergence, the stand was thinned down to the right plant density (according to the layout). During

Corresponding author:
Kazimierz Noworolnik
e-mail: knoworolnik@iung.pulawy.pl
tel. +48 81 8863421 ext. 208

Received 28 November 2010

growth, the plants were mechanically protected against lodging. Weeds were manually removed. Diseases and pests were controlled by using chemical plant protection agents.

Once harvested, the barley crop was evaluated for grain yield, grain yield components, protein content (Kjeldahl method; N × 6.25) and seed plumpness (Vogel sieves). Protein yield was also calculated. The results were statistically evaluated by the analysis of variance, and the significance of differences was evaluated using Tukey's test.

RESULTS AND DISCUSSION

The research showed a significant impact of sowing rate on grain yield of spring barley cultivars and main yield components (Tables 1 and 2). Grain yield increased together with an increase of sowing rate to 450 seed m^{-2}, but in 2004–2005 yield increase (averaged across cultivars) at that sowing rate compared to the sowing rate of 350 seed m^{-2} was more like a tendency. Higher yield increase at high sowing rate compared to medium sowing rate were found for: Widawa, Mauritia, Nagradowicki and Tocada. The increase of grain yield with sowing rate was the result of the increase of ear number per area unit of all cultivars (to the highest degree in the cultivar Mauritia). Grain weight per ear (averaged across cultivars) was significantly higher at low sowing rate. The interaction between sowing rates and particular cultivars occurred (in 2006–2007) for grain weight per ear. A negative impact of high sowing rate on this value was found for Toucan and Mauritia, whereas its changes at Nagradowicki and Tocada were insignificant. The increase of sowing rate caused the decrease in number of grains per ear of the cultivars investigated in 2004–2005 (Table 1), whereas for those investigated in 2006–2007 the interaction between a sowing rate and a cultivar occurred. Number of grains in Toucan, Mauritia decreased at high sowing rate, while it increased for Nagradowicki and Tocada cultivars (Table 2).

In scientific literature we cannot find much information on the comparison of the reaction of new spring barley cultivars to sowing rate. It is mainly concerned with the results of microplot experiments, continually performed in IUNG-PIB in Puławy (Kozłowska-Ptaszyńska, 1993; No-

Table 1. Effect of sowing rate on yielding and yield components of spring barley cultivars (2004–2005).

Cultivar	Sowing rate [seed number per m^2]	Grain yield [g m^{-2}]	Ear number per m^2	Grain yield per ear [g]	Grain number per ear
Nadek	250	791	922	0.86	20.5
	350	866	1090	0.79	18.2
	450	915	1216	0.75	17.8
	mean	857	1076	0.80	18.8
Sebastian	250	860	941	0.92	19.3
	350	946	1132	0.84	17.2
	450	991	1235	0.80	17.0
	mean	934	1103	0.85	17.8
Widawa	250	856	953	0.90	21.1
	350	914	1122	0.82	20.0
	450	975	1264	0.77	19.2
	mean	915	1113	0.83	20.1
Kirsty	250	803	947	0.85	21.1
	350	886	1121	0.79	20.3
	450	927	1238	0.75	20.0
	mean	872	1102	0.79	19.1
Mean	250	828	941	0.88	20.6
	350	906	1116	0.81	18.9
	450	952	1238	0.77	18.3
LSD(0.05) for:					
sowing rate		54	86	0.06	1.4
cultivar		51	ns	0.05	1.3
interaction		59	ns	ns	1.8

ns – non significant

Table 2. Effect of sowing rate on yielding and yield components of spring barley cultivars (2006–2007).

Cultivar	Sowing rate [seed number per m^2]	Grain yield [g m^{-2}]	Ear number per m^2	Grain yield per ear [g]	Grain number per ear
Toucan	250	622	792	0.79	19.8
	350	710	975	0.73	18.7
	450	771	1107	0.70	18.1
	mean	701	958	0.74	18.9
Mauritia	250	632	698	0.90	19.3
	350	770	963	0.80	17.4
	450	863	1125	0.76	17.6
	mean	755	929	0.82	18.1
Nagrado-wicki	250	695	820	0.85	19.0
	350	880	1042	0.84	20.5
	450	972	1170	0.83	20.8
	mean	850	1011	0.84	20.1
Tocada	250	683	687	0.99	22.0
	350	847	939	0.94	21.6
	450	970	1004	0.96	23.1
	mean	833	876	0.96	22.2
Mean	250	657	749	0.88	20.1
	350	798	980	0.83	19.6
	450	898	1102	0.81	19.9
LSD(0.05) for:					
sowing rate		62	76	0.05	ns
cultivar		58	72	0.07	1.4
interaction		71	ns	0.08	1.7

ns – non significant

worolnik, 2007b; Noworolnik, Leszczyńska, 1998, 2000, 2004b) but which involved cultivars older than the ones investigated in this work. It was recorded that the cultivars with weaker tillering, mostly malting ones, show higher increase in grain yield at high sowing rate. The cultivars with stronger tillering show higher plant death rate at high sowing rate. New cultivars of spring barley show less varied reactions to sowing rate (concerning grain yield and its structure) in comparison with older cultivars from the previous research. A high number of ears of some cultivars per area unit under higher sowing rate generally cause a higher decrease in grain yield and grain number per ear. Different reactions of different barley cultivars to sowing rate due to different properties of those cultivars were found also in field experiments in Poland (Noworolnik, 2007b; Noworolnik, 2004a) and abroad (Farack, Hansel, 1987; Jedel, Helm, 1995, Zhao et al., 1988).

Sowing rate-dependent changes in protein content varied from cultivar to cultivar (Tables 3, 4). Non significant differences in protein content were recorded for the cultivars Nadek, Sebastian, Toucan and Mauritia, whereas an increase of this value at high sowing rate was found for Widawa, Kirsty, Nagradowicki and Tocada. Sowing rate did not significantly affect the content of proteins in grains averaged across cultivars. The increase in sowing rate resulted in an increase of protein yield in all the cultivars. A positive significant impact of sowing rate on grain plumpness was found for Nadek, Sebastian, Toucan, Mauritia and for the average of all cultivars (Tables 3, 4). The weight of 1000 of grains did not change significantly under the influence of sowing rate in the cultivars investigated in 2004–2005. A significant negative impact of high sowing rate on the mass of 1000 of grains was found for Nagradowicki, Tocada and for the average of the cultivars investigated in 2006–2007. Slight but varied differences of protein level in the grains of the investigated cultivars under the influence of sowing rate were found also in other works (Bertholdsson, 1999; Eagles et al., 1995; Noworolnik, 2003, 2007a, 2007b, 2008; Pecio, 2002; Zhao et al., 1988). There was also an increase in grain plumpness of spring barley (Bertholdsson, 1999; Eagles et al., 1995; Pecio, 2002) and slight decrease of TGW (Jedel, Helm,

Table 3. Effect of sowing rate on grain quality features of spring barley cultivars (2004–2005).

Cultivar	Sowing rate [seed number per m^2]	Protein content [d.m.%]	Protein yield [kg m^{-2}]	Grain fraction >2.5 mm [%]	1000 grain weight [g]
Nadek	250	11.9	94	79	41.9
	350	11.4	99	86	43.7
	450	11.6	106	89	42.2
	mean	11.6	100	85	42.6
Sebas-	250	10.7	92	82	47.5
tian	350	10.5	99	87	48.8
	450	10.8	107	89	47.3
	mean	10.7	99	86	47.9
Widawa	250	10.2	87	78	42.6
	350	10.8	99	79	40.8
	450	11.1	108	82	40.2
	mean	10.7	98	80	41.2
Kirsty	250	10.5	84	80	40.2
	350	11.0	97	82	39.0
	450	11.2	104	83	39.2
	mean	10.9	95	82	39.5
Mean	250	10.8	89	80	43.1
	350	10.9	99	84	43.1
	450	11.2	106	86	42.2
LSD(0.05) for:					
sowing rate		ns	7	5	ns
cultivar		0.6	ns	5	2.7
interaction		0.7	ns	7	ns

ns – non significant

Table 4. Effect of sowing rate on grain quality features of spring barley cultivars (2006–2007).

Cultivar	Sowing rate [seed number per m^2]	Protein content [d.m.%]	Protein yield [kg m^{-2}]	Grain fraction >2.5 mm [%]	1000 grain weight [g]
Toucan	250	10.8	67	77	39.7
	350	11.0	78	84	39.0
	450	11.0	85	87	38.4
	mean	10.9	77	83	39.0
Mauritia	250	10.8	68	81	46.7
	350	10.7	82	85	46.2
	450	11.1	96	90	43.5
	mean	10.9	82	85	45.5
Nagra-	250	11.5	80	80	44.6
dowicki	350	12.2	107	83	41.2
	450	12.6	122	86	39.8
	mean	12.1	103	83	41.9
Tocada	250	11.0	75	78	45.1
	350	11.3	96	81	43.5
	450	11.8	114	82	41.7
	mean	11.4	95	80	43.4
Mean	250	11.0	73	79	44.0
	350	11.3	91	83	42.4
	450	11.6	105	86	40.8
LSD(0.05) for:					
sowing rate		ns	8	6	2.9
cultivar		0.6	9	ns	2.7
interaction		0.8	ns	8	3.3

ns – non significant

1995; Noworolnik, 2003, 2007a, 2007b, 2008; Noworolnik, Leszczyńska, 1998, 2000, 2004a, 2004b; Pecio, 2002) along with the higher sowing rate.

Grain yield and the values of its components varied from cultivar to cultivar. A higher grain yield (averaged across sowing rates) was recorded for the cultivars Sebastian, Nagradowicki and Tocada (Table 1, 2). In the case of Nagradowicki, it was the result of the highest number of ears per area unit; Sebastian and Tocada showed a high grain weight per ear; Sebastian, due to a very high 1000 grain weight (close to Mauritia); and Tocada due to a very high grain number per ear. The lowest weight per 1000 grains was found in Toucan and Kirsty cultivars.

The highest protein level of the grain was found for Nagradowicki, followed by Nadek and Tocada (Table 3, 4). A high protein yield was given by Nagradowicki, Nadek, Sebastian and Widawa. A high grain plumpness (an important feature of malting quality) was found in Nadek, Sebastian and Mauritia, the lowest in Tocada and Widawa. The comparison of yield, yield component and quality traits of different barley cultivars by COBORU cultivar experiments (Lista..., 2008; Wyniki..., 2009) are mostly consistent with the results of this work.

CONCLUSIONS

1. All the cultivars of spring barley reacted positively to an increase in sowing rate from 250 to 450 seed m^{-2}. Widawa, Mauritia, Nagradowicki and Tocada cultivars showed a higher yield increase at high sowing rate in proportion to the average sowing rate of 350 seed m^{-2}.
2. The increase of grain yield at high sowing rate was the result of the increase in the number of ears per area unit of all cultivars (to the highest degree in cv. Mauritia). The weight of grain per ear (averaged across cultivars) was significantly higher at low sowing rate.
3. The protein content increase in grain at high sowing rate was recorded in the cultivars Widawa, Kirsty, Nagradowicki and Tocada. A significant positive effect of high sowing rate on grain plumpness was recorded for Nadek, Sebastian, Toucan and Mauritia.

REFERENCES

Bertholdsson N.O., 1999. Characterization of malting barley cultivars with more or less stable protein content under varying environmental conditions. Eur. J. Agron., 10: 1-8.

Eagles H., Bedgood A., Martin P., 1995. Cultivar and environmental effects on malting quality in barley. Aust. J. Agric. Res., 46: 831-844.

Farack M., Hansel A., 1987. Ergebnisse agrotechnischer Prufungen zu Sommergerste in Vorgebirgslagen. Feldversuchsvesen, 1: 30-41.

Jedel P.E., Helm J.H., 1995. Agronomic response to seeding rate two-and six-rowed barley cultivars in Central Alberta. Can. J. Plant Sci., 75(2): 315-320.

Kozłowska-Ptaszyńska Z., 1993. Changes in the structure and architecture of plant canopy of two- and six-rowed spring barley cultivars as affected by seeding density. Pam. Puł., 102: 65-76. (in Polish)

Lista opisowa odmian. Cz. 1. Zboża. 2008, COBORU.

Noworolnik K., 2003. The effect of some agricultural factors on spring barley yielding in various environmental conditions. Monogr. Rozpr. Nauk., Puławy, 8: 66 pp. (in Polish)

Noworolnik K., 2007a. Kształtowanie jakości ziarna jęczmienia jarego browarnego poprzez zabiegi agrotechniczne. Stud. Rap. IUNG-PIB, 9: 65-75.

Noworolnik K., 2007b. Grain and protein yield of spring barley cultivars depending on sowing rate. Acta Agrophys., 10(3): 617-623. (in Polish)

Noworolnik K., 2008. Yielding and protein content in grain of brewery cultivars of barley depending on sowing rate. Fragm. Agron., 1(97): 278-287. (in Polish)

Noworolnik K., Leszczyńska D., 1998. Comparison of response of spring barley cultivars to sowing date and sowing rate. Pam. Puł., 112: 163-168. (in Polish)

Noworolnik K., Leszczyńska D., 2000. Response of new spring barley cultivars to sowing rate. Biul. IHAR, 214: 159-162. (in Polish)

Noworolnik K., Leszczyńska D., 2004a. Grain and protein yield of naked and husked spring barley under various environment conditions as affected by sowing rate. Pam. Puł., 138: 117-123. (in Polish)

Noworolnik K., Leszczyńska D., 2004b. Effect of sowing rate and sowing date on grain yield and its structure in spring barley cultivars. Short communication. Biul. IHAR, 231: 357-363. (in Polish)

Pecio A., 2002. Environmental and agrochemical limitations of the grain yield and quality of malting barley. Fragm. Agron., **4(76):** 4-112. (in Polish)

Wyniki porejestrowych doświadczeń odmianowych. Zboża jare, 2009. COBORU, p. 66.

Zhao D.C., Tang Z.K., Zhu F.T., Shi C. Effect of multiple cultural factors on the field and grain quality of malting barley. Scienta Agric. Sinica, 21(6): 67-73.